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TECHNICAL INFORMATION BOOKLET No. 4

The Technique of Low Temperature Brazing and Bronze Welding Copper Tube

Issued by
NEW ZEALAND INDUSTRIAL GASES LIMITED

(Revised 1961)

3-00

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INTRODUCTION

Part I—THE SILVER BRAZING ALLOYS, SILFOS AND EASY-FLO

Both Silfos brazing alloy and Easy-Flo brazing alloy, and the special fluxes recommended for use with them, are manufactured in London, England by Johnson, Matthey & Co. Limited.

This company has been established over a century, holds the honoured distinction of being licensed Melters and Assayers to the Bank of England, and has world-wide reputation as bullion refiners and manufacturers of alloys in precious metals for all industrial and scientific purposes. Johnson, Matthey & Co. Limited possess the largest Electrolytic Silver Refineries in Europe.

Extensive investigations have been made in their Research Laboratories into problems connected with the joining of metals. It has been proved that Silfos and Easy-Flo brazing alloys have been successfully employed to overcome many difficulties, and these materials are now being used in many parts of the largest engineering works throughout the world.

New Zealand Industrial Gases Limited, through their operating branches, act as official distributors throughout New Zealand.

Johnson, Matthey & Co. Limited, specialists in the metallurgy and production of the precious metals, and New Zealand Industrial Gases Limited, specialists in the production and uses of industrial gases, are thus co-operating in placing at your disposal their combined experiences in the use of Silfos and Easy-Flo Low Temperature Brazing Alloys.

Part II—THE BRONZE WELDING OF COPPER

A further chapter in this booklet deals briefly with the use of bronze on copper and copper pipe.

New Zealand Industrial Gases Limited, through their overseas connections, can offer a wide selection of bronzes to suit all purposes.

Bronzes vary in their compositions and should be accordingly selected for the particular application on hand. The Technical Service of New Zealand Industrial Gases Limited is available to assist you on any problems arising from the selection or application of these materials.

PART 1

SILFOS BRAZING ALLOY

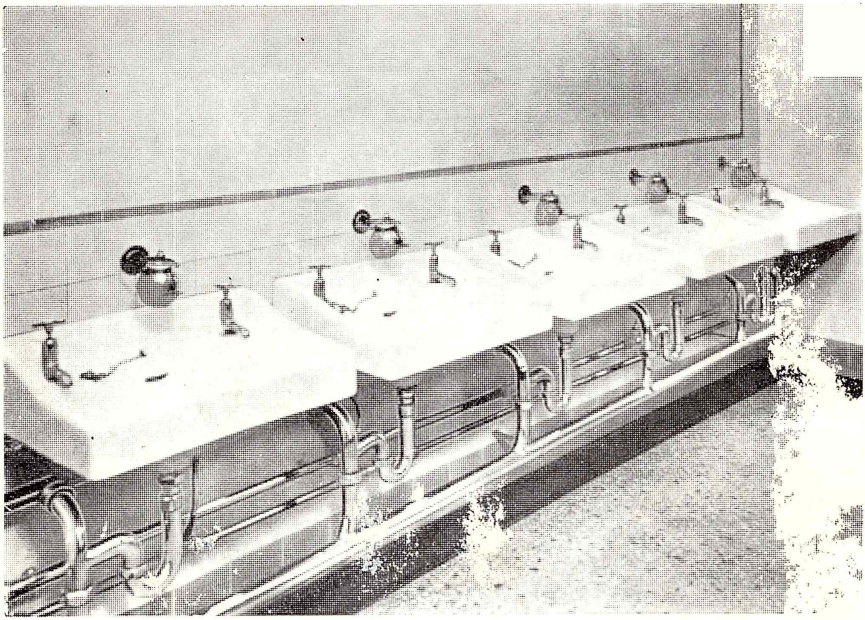


FIG. 1—Lavatory basin unit with copper supply and waste units brazed with Silfos
(Acknowledgement to Messrs. Johnson, Matthey & Co. Ltd.)

GUARANTEE : Silfos is produced in the works SOLELY engaged in the refining, alloying, melting, rolling and fabrication of the precious metals, which demand the closest technical control. Silfos is prepared from the purest metals obtainable. Consistency of alloys and accuracy of metal content are guaranteed.

USES : Silfos is a low temperature brazing alloy consisting of copper, silver and phosphorus, and has a remarkable affinity for copper and copper alloys, such as brass and bronze, alloying readily with each of these metals to form neat, strong joints in such articles as :—

Brass castings.
Brass nipples to copper pipes.
Brass sheet metal work.
Brass unions to copper pipes.
Bronze castings.
Copper domestic appliances.
Copper electrical equipment.
Copper hot water equipment.
Copper steam installation.
Copper plant and equipment.

Silfos is not recommended for use with Steel or Nickel alloys.

PHYSICAL PROPERTIES (Tests on samples "as Cast"):

Melting Point	705° C. Liquidus
Brinell Hardness	187
Reduction in Area	23%
Elongation	10%
Yield Point	40 tons per square inch
Maximum Stress	46 tons per square inch

Silfos is approved by the British Air Ministry for use in the construction of aircraft.

The low melting point and free flowing characteristics give Silfos excellent penetration and neat finish.

APPEARANCE : Silfos strips have a dull coppery appearance with a tendency to brittleness in the rod form.

EASY-FLO BRAZING ALLOY

Easy-Flo can be used with advantage in conjunction with the following metals and it is the most satisfactory brazing alloy to employ when making joints between dissimilar metals.

Copper and Copper Alloys

Brasses
Bronzes
Gunmetals
Manganese-Bronzes
Nickel Copper Alloys
Phosphor-bronzes
including such proprietary alloys as :
Delta-Brand Metals
Immadium Metals
Kunial Brasses
Tungum Metals

Nickel and Nickel Alloys

Cupro Nickels
Nickel-Chromium Alloys
Nickel-Silver (German Silver)
Including such proprietary alloys as :
Cronite
Inconel
Invar
Monel Metal
Nichrome

Wrought Iron and Steels of All Classes

Mild Steels (low carbon)
Silver Steels (high carbon)
Stainless Steels
Tool Steels
Heat Resisting Steels
Constructional, Carbon, and Alloy Steels of all types incuding such proprietary alloys as :
Armco Iron
Anka Stainless Steel
Silver Fox Stainless Steel
Staybrite Stainless Steel

ELECTRIC RESISTANCE ALLOYS

Including :
Constantin
Eureka
Ferry
Manganin, etc.

CEMENTED CARBIDES AND HARD FACING ALLOYS

Including
Carboloy
Cutanit
Stellite
Widia, etc.

EASY-FLO Can be Used Under Certain Conditions with :

Aluminium Brasses
Aluminium Bronzes
Cast Irons
Malleable Cast Irons

EASY-FLO Will Not Make Joints with :

Aluminium
Aluminium Alloys
Lead
Tin
Zinc-base Alloys
and all other metals and alloys which have a melting point below 650° C.

N.B.—In all cases, Easy-Flo flux must be employed with Easy-Flo Silver Brazing Alloy to obtain maximum efficiency.

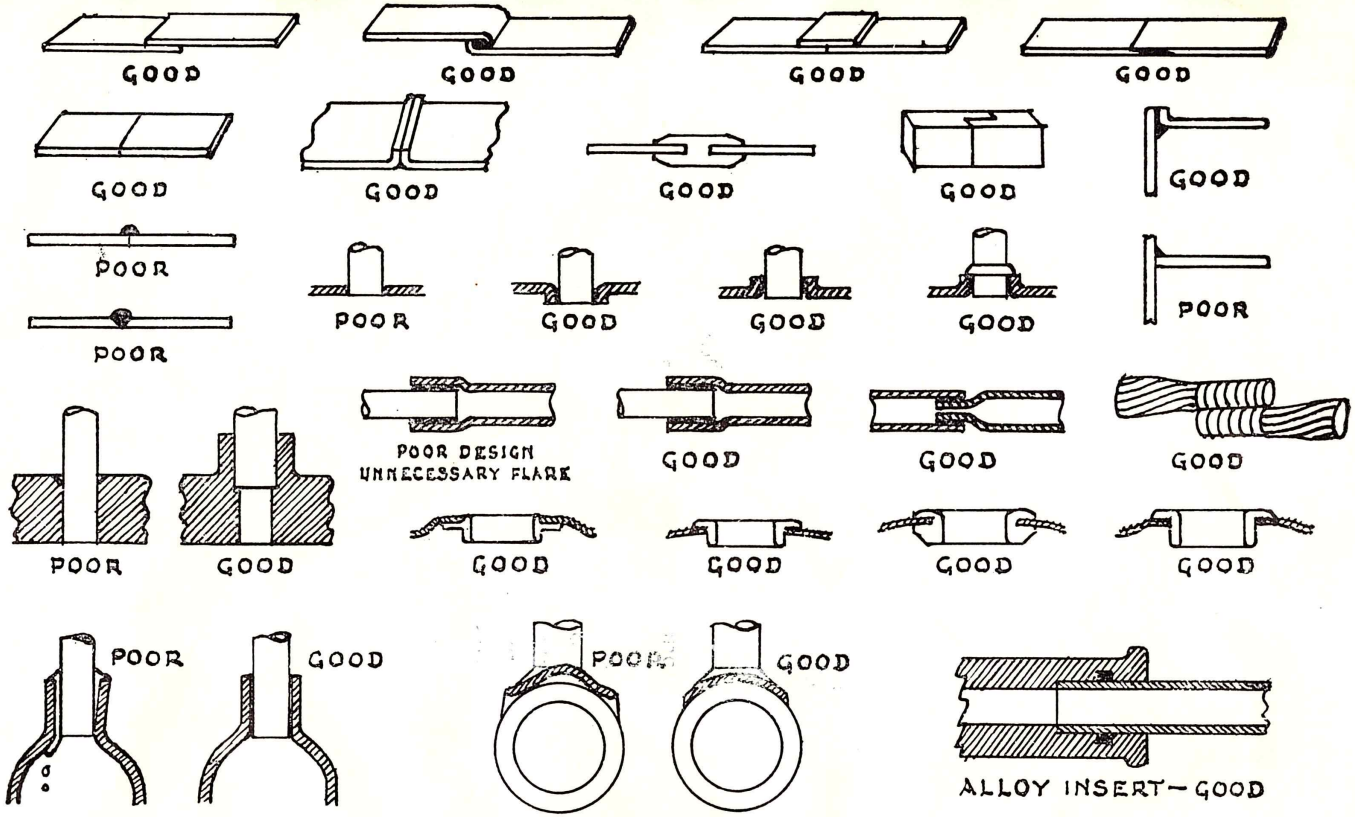


FIG. 2.—THESE ARE TYPICAL EXAMPLES OF GOOD AND BAD DESIGNS. THE REASONS WHY WILL BE FOUND IN THE ACCOMPANYING TEXT.

PHYSICAL PROPERTIES (Tests on samples "as Cast") :

Melting Point	630° C. Liquidus
Brinell Hardness	131
Reduction in Area	40%
Elongation	35%
Yield Point	20 tons per square inch
Maximum Stress	30 tons per square inch

Easy-Flo is approved by the British Air Ministry for use in the construction of aircraft.

APPEARANCE : Easy-Flo strips have a bright silvery colour, and may be bent without breaking.

Scarf joints can be made as strong as the metal which is joined provided that sufficient overlap is allowed. Joints in band saws of strengths of 63 tons per square inch are readily obtained, and these joints will withstand the repeated bending.

Because of its ductility, Easy-Flo is most suitable for use where the join is subjected to bending, vibration or shock and joints in many metals such as copper, brass, etc., can subsequently be worked cold without impairing the strength of the joint.

DESIGNING THE JOINT

The same principles apply in designing the joint, for both Silfos and Easy-Flo.

Provided the metal surfaces are clean and properly protected by flux from oxidising during pre-heating, Silfos and Easy-Flo can penetrate quickly into narrow openings.

FIG. 3. Capillary action can spread these alloys throughout an entire joint, rapidly and completely, provided the gap is small. Fig. 3 shows the relation of joint thickness to tensile strength, based on butt joints of stainless steel to stainless steel. It will be seen that with a clearance of .0015 inch the joint has a tensile strength of 134,000 lbs./sq. in. In the extreme case a driving fit will stop any chance of the capillary action taking place and the joint has to rely for its strength on a small fillet. This remarkable strength with an alloy which has in itself a tensile strength of only 30 tons/sq. in. in cast form occurs because the alloy itself is in a thin film alloyed to both surfaces.

These recommended clearances are easy and inexpensive to obtain and are essential for the best possible joints, quite apart from the fact that they offer the greatest economy.

The butt, scarf and lap or shear joints are the three types generally employed, but the lap or shear joint is the most commonly used and is recommended.

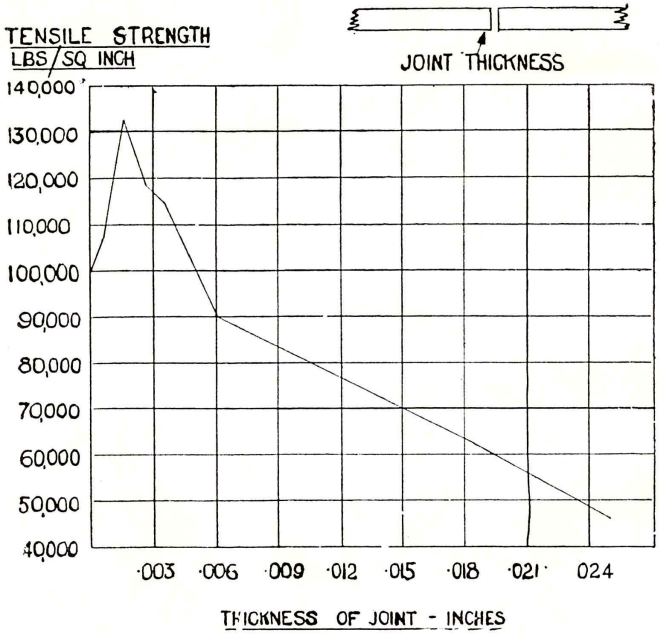


FIG. 3.

SCARF JOINTS

This is another form of butt joint which may be used. joint surfaces are bevelled to an angle of less than 90°. This design provides larger joining surfaces than butt construction and gives higher strength without making the joint thickness greater than that of the metals to be joined. Parts can be easily held in place with clamps while brazing. Joints of this type are used on such work as the joining of band saws, pipe fabrication, etc.

SHEAR TYPE JOINTS

These are the most satisfactory because they permit incorporating any desired factor of safety by varying the amount of lap. Lap joints also offer better resistance to corrosion due to the small area of alloy exposed. Joints are easily held in place for brazing and tolerances are readily controlled.

A little pressure assures complete bonding in joining flat parts. Clearance and capillary action become the controlling factors where tubular members are to be joined and pressure cannot be exerted.

The depth of shear required will vary according to the strength of the metals to be joined and the factor of safety desired. The formular commonly used in figuring shear depth is :—

$$\text{Depth of shear} = \frac{W\,(D-W)\,YT}{LD}$$

Where D = Shear diameter.

Where W = Wall thicknpess of weakest member.

Where Y = Factor of Safety.

Where T = Tensile strength of weakest member.

Where L = Shear strength of silver brazing alloy.

Note : (a) Factor of safety of 5, i.e., Y = 5, is commonly used.
(b) Shear value of silver brazing alloy.

An arbitrary minimum value of 25,000 p.s.i. shear value is usual as this is the minimum which can be expected form all silver brazing alloys with appreciable amounts of silver.

EXAMPLE :

To find the depth of shear necessary when joining a $\frac{3}{4}$" copper pipe with 0.064 wall thickness to $\frac{3}{4}$" steel tube. Here the copper is the weaker material, which has a tensile strength of 33,000 p.s.i., hence, T = 33,000
W = 0.064

Therefore, depth of shear =

$$= \frac{0.064\,(\frac{3}{4}" - 0.064)\ 5 \times 33{,}000}{25{,}000 \times \frac{3}{4}}$$

$$= \frac{0.064\ (0.75 - 0.064)\ 5 \times 33{,}000}{25{,}000 \times 0.75}$$

= 0.0386 inches
or 0.4 inches

Lap Joining of Flats :

Here the formula is simplified to—

$$\text{Depth of shear} = \frac{YTW}{L}$$

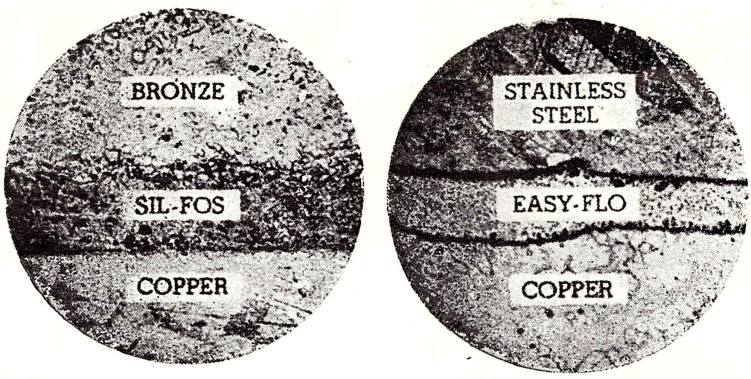


FIG. 4—The two photographs show typical joints: (1) between copper and bronze with Silfos, and (2) a stainless steel to copper joint made with Easy-Flo. The penetration into the metal surfaces shown accounts for the high strengths these alloys provide in joining metals.

A type of joint, after selection, can be adapted in many ways to the work in hand. A number of basic designs are shown in Fig. 2. Note particularly the high hub flange shown on the left-hand side (front row).

In order to make the joint marked "Poor" it would be necessary to heat all the way through the heavy mass to which the tube is joined. An alteration in design to that marked "Good" allows the relatively thin high hub to be heated rapidly and joined to the tube without bringing the heavy section to brazing heat.

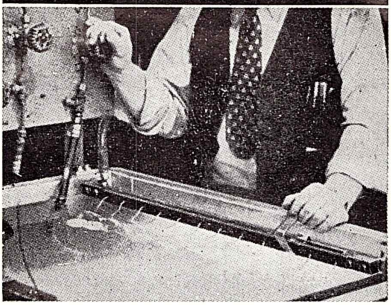
Just above these flange designs are two illustrations marked "Poor". The top one shows a bead of alloy along the joint.

This requires far more alloy than is necessary, and the bead which in reality is a casting, does not give as high strength as would be secured if a thin film of alloy were flowed between the surfaces to be joined. Likewise, the vee-shaped groove below gives the strength of a casting rather than the higher strength of a thin film alloyed with the metals joined.

BUTT JOINTS

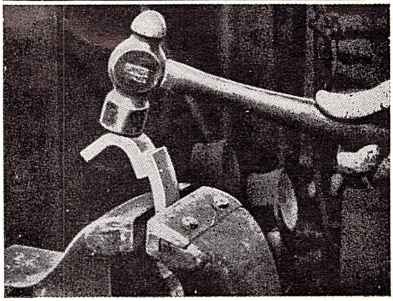
These are used in applications where the double thickness of a lap or shear type of joint is undesirable, and well-made butt joints can be used with good results if a few precautions are watched closely. The surfaces to be joined should be cut square and even, so that when pressed together, they will provide the close clearance required for high strength. Joints of this type are strong and reliable if made under proper production conditions.

LEAK-TIGHTNESS



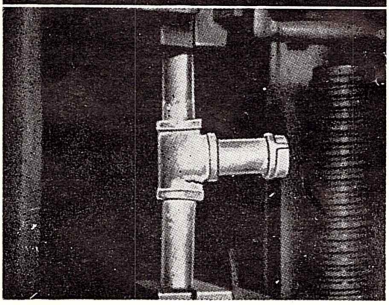
Leak-tightness is vital in heater control diaphragms. After brazing, these diaphragms are given a pressure test under water. Rejects have been reduced to less than 1%. There have been no complaints from the field.

DUCTILITY



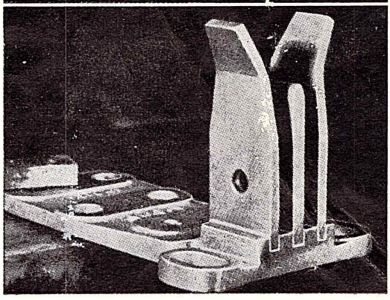
The ductility of Sil-Fos or Easy-Flo joints can be readily tested. Place a joint in a vise and bend one side, then the other, until the free ends meet. If the metal is of light gauge, twist the joint and hammer it. The joint usually stands up longer than the metal.

STRENGTH



This Sil-Fos brazed tee withstood a tensile pull of 18,000 pounds. The fitting parted but the joints held firm. This is typical of the strength well designed Sil-Fos or Easy-Flo joints will give—they're stronger than the metals joined.

HIGH CONDUCTIVITY



Sil-Fos and Easy-Flo joints give higher electrical conductivity than base metal brazed joints. With a lap 1½ times the cross sectional area, copper to copper joints are approximately 6% to 7% less resistant than copper. Resistance of butt joints is 4% to 18% more than copper.

PREPARATION

It is important that any oil or grease be removed from the vicinity of parts to be joined. The use of Trichlorethylene or Carbon Tetrochloride makes this operation quick and easy. Care should be taken by the operator that he does not touch the cleaned surfaces with greasy hands or material. This is a common cause of trouble.

Rust, scale, etc., can be removed by filing, grinding or by emery cloth.

Special methods may be adopted as follows for large production :—

Steel and Iron (Easy-Flo) :

Grease and oxide or scale can be removed by dipping in or washing with a solution of 5% sulphuric acid with one ounce to the gallon of potassium bi-chromate. This solution will attack oxides but it does not attack the metal, and, therefore, risks of over-pickling are minimised.

Brass (Easy-Flo or Silfos, according to design) :

Ten per cent. sulphuric acid solution. Ten minutes immersion is adequate, although not always necessary, depending on the amount of cleaning required. Wash off all acid solution when the metal is clean. Care should be exercised to avoid unnecessary pickling by this solution, otherwise the metals will be attacked. This should be borne in mind, particularly if the articles have fine screw threads.

Copper (Silfos recommended, but Easy-Flo can be applied for special applications) :

Copper needs only to be free from grease or dirt. Silfos used without flux will reduce copper oxides, except when extremely heavy sections are involved. Prolonged heating of such parts may create voluminous copper oxides, with which the use of Silfos flux is recommended.

It is always necessary to use Easy-Flo flux, when using Easy-Flo.

These fluxes are adequate to reduce copper oxide without the necessity for any chemical or undue mechanical cleaning.

Stainless Steel (Easy-Flo) :

Three parts sulphuric acid, one part nitric acid and ten parts water. Immerse until oxides are removed, and then carefully wash off all acid solution.

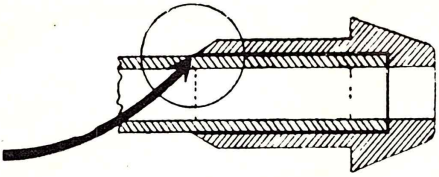
Tungsten Carbide Tips for Machine Tools (Easy-Flo) :

Etch with a solution of one part of hydroflouric acid, four parts nitric acid, afterwards wash well to remove acid solution.

Aluminium Bronzes (Easy-Flo or Silfos, according to design and metal specification) :

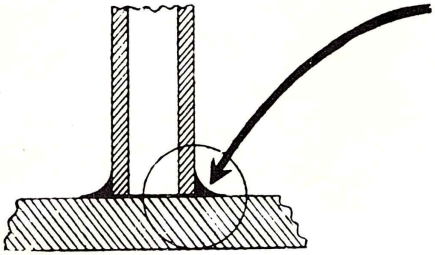
Aluminium bronzes containing about 10% aluminium are best cleaned mechanically with a file or emery cloth, or by grinding. Make the joint as soon as possible after cleaning before further oxides have had an opportunity of forming.

NIPPLE TO TUBE JOINTS



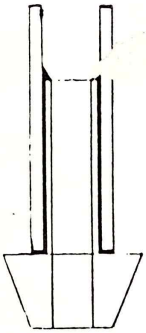
1

1. A built-up fillet is unnecessary on this type of joint where adequate strength is imparted by the overlapped joint area.



2

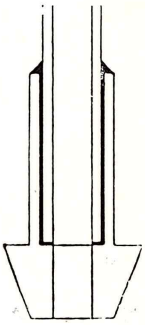
2. A fillet is required here to avoid stress concentration (due to bending, vibration, or impact) at the point where a marked change of section occurs.



3

3. It is difficult to make a sound torch brazed joint with this type of assembly where the operator cannot see what is happening.

4. Try always to use joints of this type where the operator CAN see exactly where his brazing material is going. Do not forget to apply paste flux to the end of the tube before putting on the nipple.



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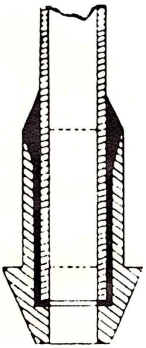
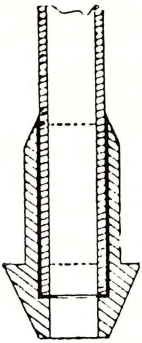


5

5. Large clearances between parts, and big fillets are wasteful of both material and time, apart from the risk of running the brazing material right through and out of the bottom if your heat control is not very good.

6. Joints will be constantly sound if regular, close clearances are maintained. Production rates will increase also.



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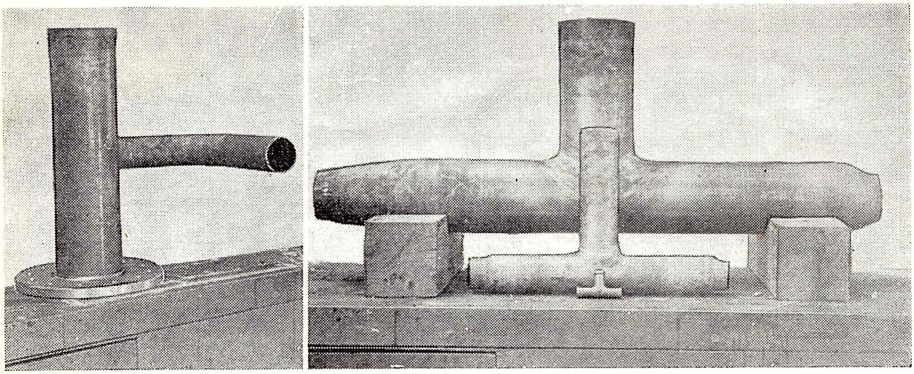


(Acknowledgements to Wellington Harbour Board.)

The above illustrations show part of a large installation being fabricated by the Wellington Harbour Board. In all there is a total length of 580ft. of 6" copper tube, approximately 3/16" in wall thickness and 18,000ft. of copper tube of smaller size varying in a range from 4" to 2½" diameter.

The assembly shown on the left-hand side shows a 6" straight and subsidiary 3" bend, being Easy-Flo brazed to a bronze flange. The brazing of the copper tube to the bend and the bend segments was done with Silfos.

The right-hand assembly shows a 6" tube and sub-assemblies silver-brazed with Silfos.

This installation is additional to a similar project which was completed some years ago, giving every satisfaction.

FITTING THE PARTS

It is desirable to fit the parts, whether the joint is of the butt or shear type, so that there is only from .002" to .004" clearance. The low temperature brazing alloys flow freely into narrow openings and the minimum of Silfos or Easy-Flo should be employed for the strongest joints to be made economically. Easy-Flo and Silfos should not be used as fillers or on vee joints.

Butt Joints :

Machine or cut the parts so that they are square or even. All parts of the surfaces between which the alloy must flow, when held by a suitable jig, should be in close contact when pressed together.

Shear or Lap Joints :

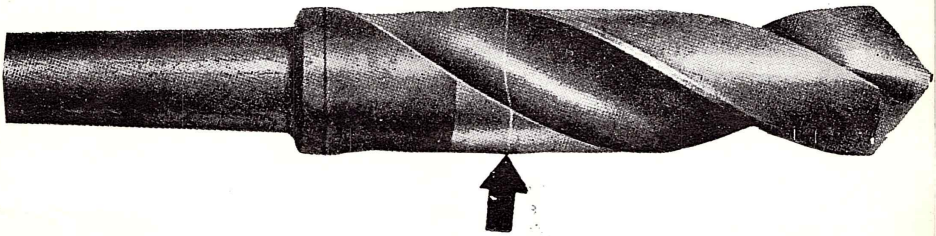
Flat surfaces should be made similarly to fit closely together ensuring intimate contact between the whole of the surfaces to be joined.

Tubes or Shaped Parts :

Arrange the correct clearances as uniformly as possible to allow the alloy to flow between the surfaces by capillary action.

Scarf Joints :

Scarf joints should be prepared like flat surfaces, with the whole of the area of the parts in close contact.



$3\frac{3}{8}$" Diameter Drill.

The broken surfaces were ground flat, thoroughly cleaned and fluxed. Parts were clamped accurately in a vertical position with a flux-covered piece of .003" Easy-Flo strip between them. The drill was heated uniformly with two torches. The flame was concentrated round the joint for a few minutes when the alloy flowed in order to get complete heat penetration.

THE FLUX AND THE FLUXING OF THE JOINT

Both Silfos and Easy-Flo fluxes have been developed after considerable research for use with their respective silver brazing alloys. A special property of great importance is that the fluxes become molten and active at temperatures very close to the melting-point of the alloys themselves. Easy-Flo flux has the advantage of causing metals such as stainless steel and Stellite alloys to be properly "wetted" by the Easy-Flo rod. During the brazing operation when the flux has become fluid it is an indication to the operator that the metals to be joined are sufficiently hot to melt the brazing alloy. The brazing rod, in silver brazing operations is not melted by the heat of the flame, but by the heat of the job itself, and thus, this indicating property of the flux is of special importance to the operator.

Ordinary brazing or bronze welding fluxes cannot be used for silver brazing alloys, as they do not become fluid or active at the low temperature range of silver brazing operations. There is a grave danger in their use that the metal will not only become overheated but that there will also be a possibility of entrapping raw flux in the joint, leading to porosity and leakage.

The silver alloy fluxes readily absorb moisture and the lid of the container should be replaced firmly after use. The flux should be mixed into a paste with cold water for best results and applied evenly to the jointing surfaces with a brush. This paste should be discarded at the end of each day and the container cleaned before fresh flux is added.

Easy-Flo flux must be used to obtain the best results on any metal when using Easy-Flo brazing alloy. Silfos brazing alloy, when used on copper, needs no flux except on heavy sections. Silfos flux should be used if Silfos is used on brass or bronze.

A standard recommendation is that flux, in paste form, be applied before heating commences, both for the joint area of the work, and the strip of brazing alloy used. Where the duration of the heating or the size of the joint make it desirable for further additions of flux to be made as the joint proceeds, such additions are best made by dipping the hot end of the strip in dry flux.

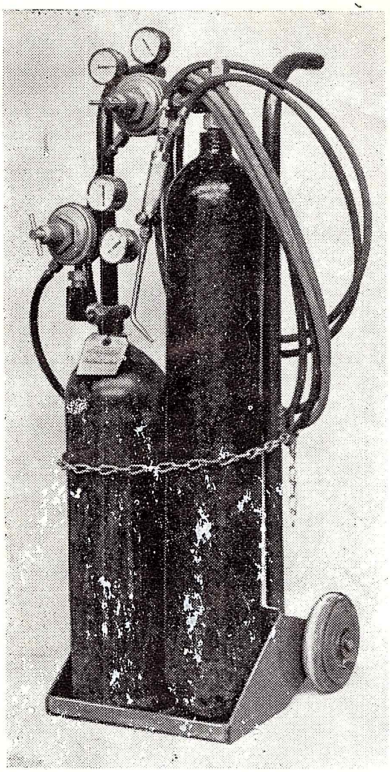
The mixing of the flux to a paste is best done by adding only just sufficient water to make a stodgy paste, which is then left for ten minutes after which the additional water required can be gauged accurately. Attempting to add all the required water at once usually results in a very thin mixture which does not carry a sufficient body of flux to the work.

Lap joints in which the clearance of gap is regular and between 0.002" and 0.008" [illegible] which have an exterior shoulder readily accessible to the [illegible] alloy strip, will give the best results. The parts should [illegible] with the flux paste before assembly if the length o[illegible]

Application of the [illegible] be sufficient with short[illegible] getting the paste flux to we[illegible] The work, in such cases, should be [illegible] torch as the flux is applied, so that the water dries out [illegible] diately, leaving the flux in the correct position. Work should be carried out in a downhand position wherever possible in order that gravity as well as capillary action may play its part in filling the joint.

HEATING

These low temperature brazing alloys can be melted by any heating medium which gives the required temperature but experience in New Zealand has shown that for most work the oxy-acetylene flame is preferred because of its easily regulated and constant nature.



Portable oxy-acetylene plant manufactured for the plumbing trade.

The portable air-acetylene outfit is preferred where portability is a consideration, especially for domestic plumbing work involving the jointing of copper pipe, using Silfos.

Recently, the importation of small 40 cu. ft. oxygen cylinders and the manufacture of a light cylinder truck specially for plumbing use has increased the popularity of oxy-acetylene in this field.

The envelope of the flame, and not the cone, should be in contact with the work when the oxy-acetylene flame is used. The operator should ensure that the flame is constantly on the move over as large a portion of the joint as can be brazed in a single run of the alloy. Overheating and loss of heat control can otherwise result.

The outer envelope of the flame should play more on the thicker component than the lighter, or on the more highly conductive metal than on the poorer conductor if the parts to be assembled are of different sections or of different metals.

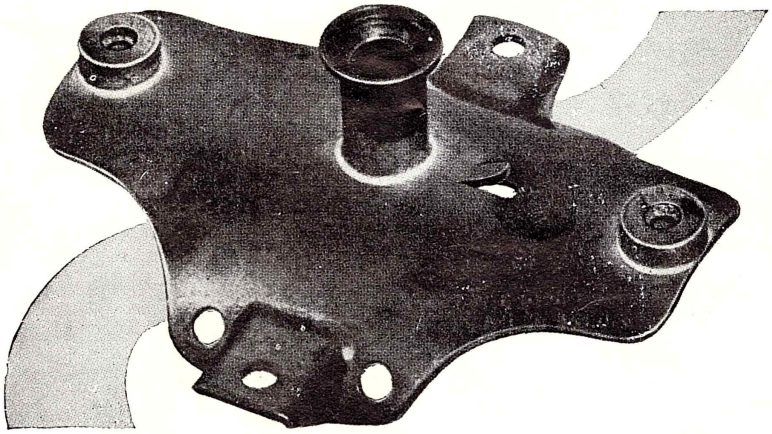
It is always best for the flame to be adjusted to the neutral condition as this is the most easily recognised and controlled flame setting.

It will be seen that the flux will first bubble and then become a thin clear liquid as heating proceeds.

As previously stated, this is an indication to the operator that the work is approaching the correct temperature for the application of the brazing material. The fluxed end of the strip should then be placed in firm contact with the joint and, if it

does not melt on contact with the work it should be removed and heating continued with the flame still in motion. The brazing material should at no time be melted in the flame and allowed to drop on the work. Once the filler metal is melting in contact with the work the strip can be fed down until the joint is slightly over-filled in order to allow for shrinkage on solidification. The main part of the heating effect of the flame should be moved, during this time to the portion of the work to which the molten metal is required to run. The brazing alloy will be attracted to the hottest part of the joint.

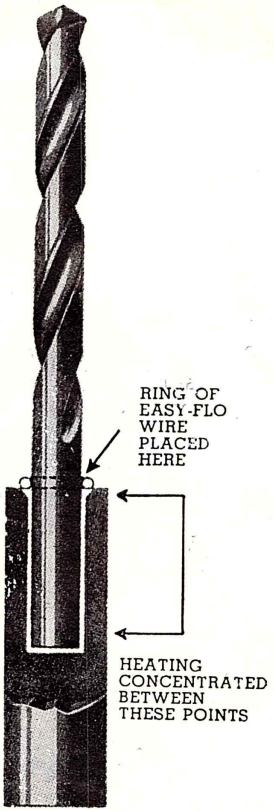
Heating should be continued until the joint is not only well filled, but the molten metal has had time to penetrate the full depth of the joint. Parts, where possible, should be placed on non-heat-conducting material in such a manner that excess heat from the part being brazed is deflected on to the next part.



This hanger bracket for a small electric motor used in aircraft is one of a long and growing list of parts formerly made from castings and forgings that have been re-designed for Easy-Flo brazed construction.

It is most important that the material should not be heated more than necessary as, not only are the parts liable to be damaged, but the brazing material itself may have its composition altered, reducing its strength.

Black patches, which may appear on the work during heating, are an indication that there has been local overheating or inadequate fluxing. Such a patch should readily disappear when dry flux is added from the brazing strip. Particularly stubborn spots can be treated by rubbing with an iron wire which has been heated and dipped in the powdered flux. This is not necessary, however, if reasonable care has been taken during the heating.



This simple inexpensive method was worked out where larger shanks were needed on drills. Cold rolled steel shanks of required O.D. were turned and drilled with a clearance of 0.002" to 0.003".

Holes and drill shanks were cleaned and fluxed. New shanks were clamped in a vertical position and drills inserted. Easy-Flo wire rings were placed as shown. Heat was applied uniformly around the outer shanks with an oxy-acetylene torch.

Poor "wetting" of the work by the brazing material usually indicates that the wrong flux has been used, that the work was not properly cleaned, that too little flux was used, or that the operator had attempted to melt the brazing strip at too low a temperature.

Pronounced pitting of the work by the brazing material usually indicates overheating. This overheating can cause excessive fuming of the flux, together with difficulty in the removal of the flux residues.

REMOVAL OF FLUX

The work should be allowed to cool until the molten brazing alloy has solidified and at this stage most non-ferrous metals can be quenched in water. Any flux left on the joint is readily removed if this quenching is done while the work is still hot, especially if the joint is brushed with a wire brush.

It is most important that no flux be left on the joint, as corrosion is likely to be set up by action of the atmosphere.

Easy-Flo flux is easily removed by washing the joint with water and scrubbing with a wire brush, while Silfos flux can be removed by washing in hot water or a weak solution of sulphuric acid. It is essential if an acid dip is used that there be a

subsequent washing with water to avoid any acid action.

The parts can be dipped for from two to five minutes in a hot 5—10% solution of sulphuric acid. This is followed by a hot rinse and wire brushing.

Acid dipping is, however, rarely required, as a wash in water followed by brushing is usually sufficient to remove all traces of flux.

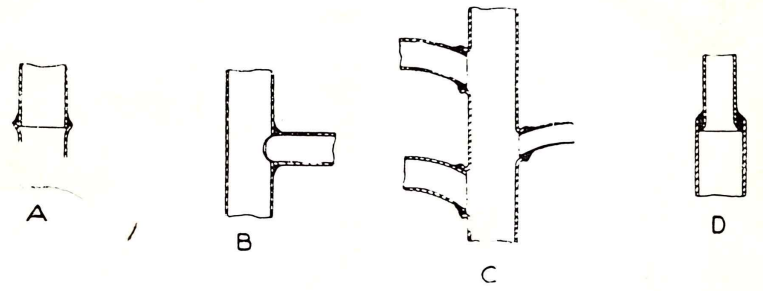
N.B.—Silfos and Easy-Flo are registered in New Zealand as trade names. The materials are manufactur
fications by Messrs. Johnson, Matthey and
Insist, for your own protection, on buying an
Silfos and Easy-Flo.

PART II

THE BRONZE WELDNG OF COPPER TUBING

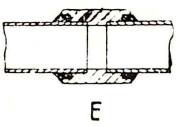
Under certain circumstances, where galvanic action is not a factor for consideration, the bronze welding of copper tubing can be satisfactorily undertaken. The company have available many types of bronze welding material and fluxes suitable for a wide range of applications. Advice can be readily obtained from any branch or representative regarding the suitability of any particular material for the application in hand.

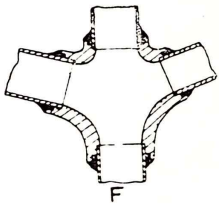
It is possible to carry out successful welds on non-deoxidised (tough pitch) material without difficulty. Copper conducts heat from the weld faster than any other material, owing to its high conductivity; thus the reduction of 200° in the temperature necessary for welding effects a very large saving in gases, as well as in time necessary to bring the work to welding temperature. The lower temperature (as compared to copper fusion welding) also reduces the risk of collapse due to the low strength of copper at high temperatures. The use of special fittings facilitate lining up and welding copper piping on the site. The accompanying diagram shows a variety of joints used on copper piping for domestic, sanitary and medical purposes.



BRONZE WELDED COPPER PIPE JOINTS

A.—Short bell butt joint.
B.—Butt tee joint.
C.—Cup tee joints.
D.—Diminishing joint.
E.—Straight weldable copper socket.
F.—Four-way unequal branch weldable copper fitting.





In recent tests carried out on copper tubes butt welded with bronze welding rod, the tubes were cold drawn after welding, without plug or mandrel, from $1\frac{1}{4}$" O.D. to $\frac{5}{8}$" O.D. The tests

were completely successful. All excess weld metal had to be removed before drawing so that this test indicates beyond doubt that the strength of a properly made bronze welded joint is at least equal to that of the tube.

Preheating :

It is necessary only on the large diameter tubes, and can be conveniently carried out with a second blowpipe.

Joint Preparation :

One of the types of joint shown in the diagrams should be used. Copper is readily swaged after cooling or quenching from red heat.

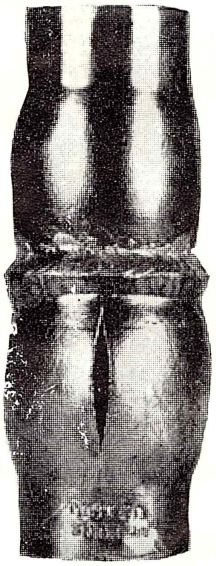
Flame :

The flame should be slightly oxidising.

Procedure :

The leftward (rod before the flame) method is used, care being taken that the work is not overheated. The copper will be found to tin very readily if this is avoided. The welding passes should be made relatively quickly and the copper base metal not held at welding temperature for too long a period.

It is not recommended that bronze welding be employed as metal of joining copper or galvanised steel pipes which are intended for the purpose of carrying hot or cold salt water, as for example on fire mains aboard ship.



Bronze welded Bell joint in copper pipe tested to destruction under hydraulic pressure of 3,000 lbs./sq. in.

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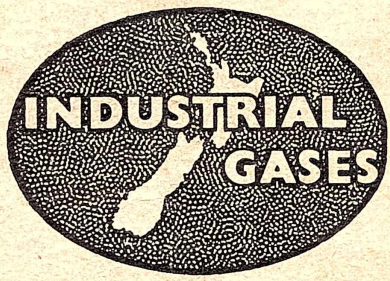
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